Zhang *et al. Microstructures* 2024;4:2024018
DOI: 10.20517/microstructures.2023.73

Microstructures

Supplementary Materials

Intrinsic supercurrent diode effect in $NbSe_2$ nanobridge

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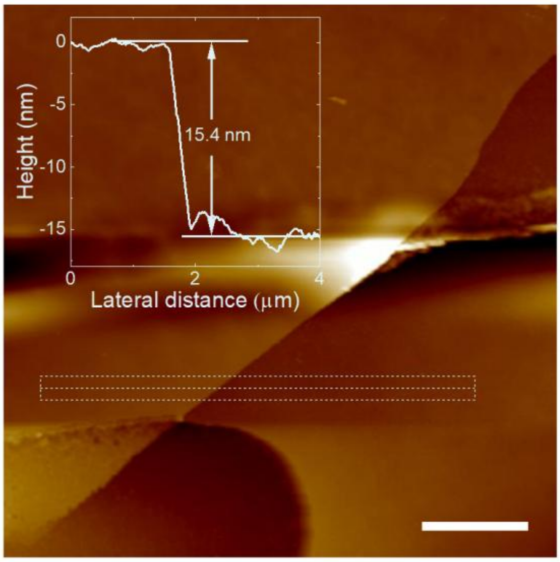
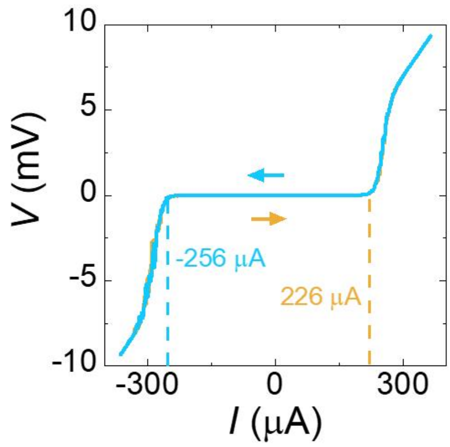
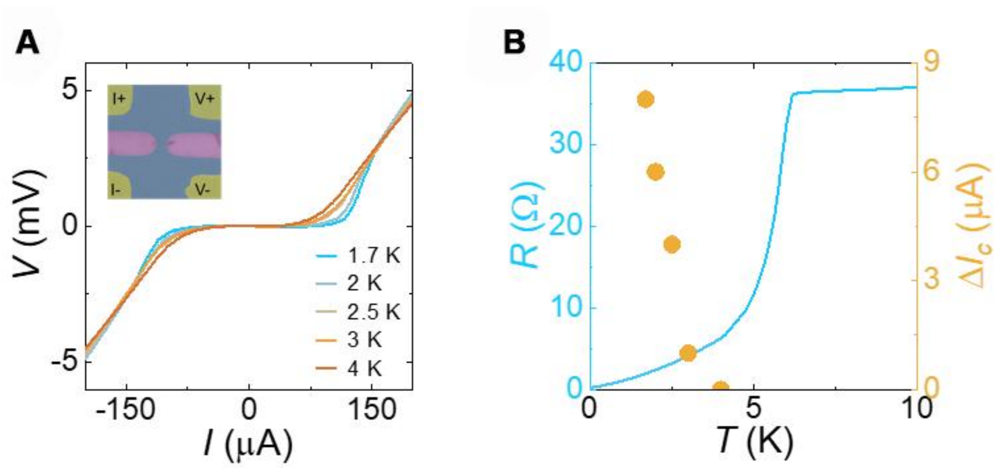


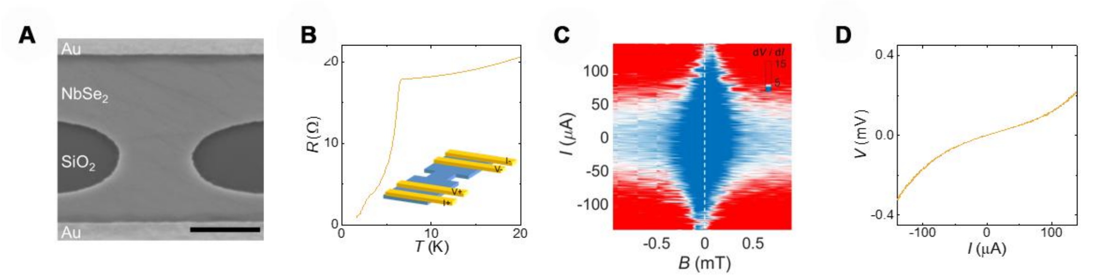
Supplementary Figure 1. AFM image of Device #1 shows the step corresponding to the thickness of $NbSe_2$ thin flake; scale bar, 1 μm. Inset: AFM height profile along the dashed rectangle with a step height of 15.4 nm. The thickness of the $NbSe_2$ flake signifies the preservation of out-of-plane rotational symmetry.



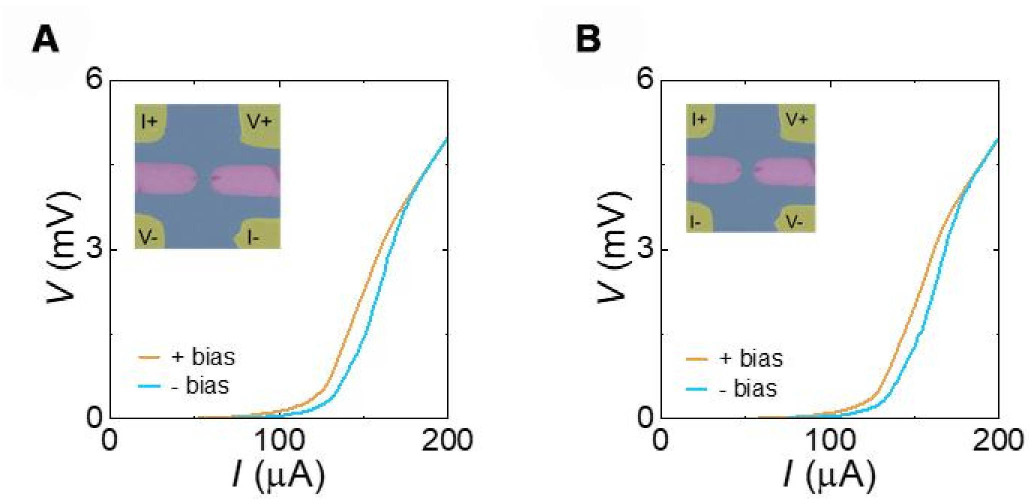
Supplementary Figure 2. The IV loop from Device #1 was measured under 3 Oe. The orange line indicates the current sweeping from negative to positive, and the orange dashed line marks the value of I_c^+ = 226 μA. The blue line indicates the current sweeping from positive to negative, and the blue dashed line marks the value of I_c^- = -256 μA. No hysteretic effect has been observed for the IV loop, indicating the absence of heating effect.



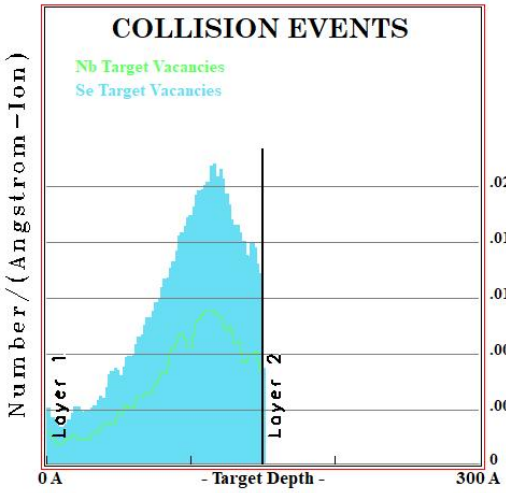
Supplementary Figure3. (A) *I-V* curves from Device #4 (700 ions/nm) have been measured at different temperatures under -2 Oe. The inset shows the measurement configuration. ΔI is defined as $\Delta I = I_c^+ - |I_c^-|$ in (B). The I_c can be obtained by the peak position of the differential resistance. With the increase of temperature, the non-reciprocal current gradually disappears and eventually disappears when the temperature reaches 4 K (orange). It is worth noting that the non-reciprocal current does not appear immediately after the $NbSe_2$ transition (6.5 K) but after the T_c of the weakly-linked junction. It is challenging to discern that, as the temperature decreases, ΔI increases. Clearly, our measurement is limited to 1.7 K. The *R*-*T* curve is extended to 0 K by quadratic fitting (blue).



Supplementary Figure 4. (A) The SEM image of the Device #5; scale bar, 1 μm; (B) The temperature-dependent resistance of the junction under an explosion of 700 ions/nm. Two transition temperatures emerge from both intrinsic $NbSe_2$ and the nanobridge. There is still a residual resistance at even 1.7 K, indicating that the Cooper pairs can hardly tunnel through the junction completely. We modified the electrode connections to address uneven currents; (C) The mapping of resistance under various current and magnetic fields. Although the junction is not completely superconductivity, a Fraunhofer pattern can be observed as evidence of the Josephson junction. However, we can hardly identify the junction as a S/I/S, S/N/S, or even S/S'/S behavior, because there is always a residual resistance; (D) The *I-V* curve under 1 Oe.



Supplementary Figure 5. The *I-V* curves from Device #4 measured under 4 Oe. The inset shows the measurement configuration. The positions of current and voltage have been switched to confirm the effects of different current directions. Although the measurement methods differ, our consistent results demonstrate the independence of the findings presented in our text from the measurement method.



Supplementary Figure 6. Monte Carlo method simulation. Helium ions were implanted into 15 nm $NbSe_2$. The ordinate indicates the probability of atomic recoil forming a vacancy, and the abscissa indicates the target depth. The layer 1 means $NbSe_2$ layer; the layer 2 means SiO_2 layer. The strong recoil of ions at the interface of layers 1 and 2 leads to more vacancies in the lower layer of $NbSe_2$, causing more damage, while the physical properties of the surface layer of $NbSe_2$ are retained. In fact, it is the anisotropic damage that facilitates the occurrence of SDE in our nanobridge. This non-uniform damage leads to a non-uniform current, further enhancing SDE.